Memo

Date:	Friday, January 28, 2022
Project:	Steese-Johansen Diverging Diamond Interchange
To:	Lauren Little, PE
From:	Kristen Keifer, PE; Will Hume, PE
Subject:	**Steese-Johansen Diverging Diamond Interchange Design Optimizations**

Executive Summary

A diverging diamond interchange (DDI) has been identified as the preferred interchange alternative by the *Steese Expressway/Johansen Expressway Interchange Alternatives Analysis*. This memorandum identifies geometric and signal operation optimizations of the baseline DDI. Microsimulation models were developed to determine operational constraints of the baseline DDI and confirm the operational benefits of recommended geometric and operational optimizations.

Baseline DDI Alternative

Geometric review and the microsimulation model of the baseline DDI identified design and operational challenges, which include:

- The crossover intersection geometry does not meet current American Association of State Highway and Transportation Officials (AASHTO) and Federal Highway Administration (FHWA) design criteria.
- The crossover intersection spacing is not ideal for signal progression.
- The large eastbound left-turn design year volume is constrained by a small left-turn radius at the northbound onramp and cannot process the forecasted 1,785 vehicles turning left during 2045 PM peak period.

Enhanced DDI Alternatives

Three enhanced DDI alternatives were developed to address the design challenges described above. Each alternative enhances the DDI geometry, improving operations.

Alternative 1 – 150-foot Eastbound Left-Turn Radius

- Increases eastbound left-turn radius from 88 feet to 150 feet
  - Increases turning speed at the eastbound onramp
  - Increases eastbound left-turn capacity to approximately 850–900 vehicles per hour per lane
- Maintains tangents through crossover intersections

- Increases spacing between crossover intersections by shifting the east crossover to the east

Alternative 2 – 230-foot Eastbound Left-Turn Radius

- Increases eastbound left-turn radius from 88 feet to 230 feet
    - Increases turning speed at the eastbound onramp
    - Increases eastbound left-turn capacity to approximately 900–950 vehicles per hour per lane
- Maintains tangents through crossover intersections
- Increases spacing between crossover intersections by shifting the east crossover to the east

Alternative 3 – 155-foot Eastbound Left-Turn Radius with East Crossover Shifted South

- Increases eastbound left-turn radius from 88 feet to 155 feet
    - Increases turning speed at the eastbound onramp
    - Increases eastbound left-turn capacity to approximately 900–950 vehicles per hour per lane
- Maintains tangents through crossover intersections
- Increases spacing between crossover intersections by shifting the east crossover to the east
- Reduces impacts to Birch Hill Cemetery
- Maintains full access to/from D Street

The enhanced DDI alternatives increase the impact on the Church of Jesus Christ of Latter-day Saints located in the southeast quadrant. All three alternatives reduce the impact on the Birch Hill Cemetery located in the northeast quadrant. No additional impacts on the northwest and southwest quadrants were identified. The increased eastbound left-turn radius results in larger bridge spans than the baseline DDI.

Enhanced DDI Traffic Operations

The microsimulation model determined the capacity of the eastbound left turn. The volume served within the microsimulation model is an indicator of capacity. The eastbound left-turn volume served for the baseline DDI and each alternative is as follows:

- Baseline DDI – 1,640 vehicles, latent demand of 145 vehicles
- Alternative 1 – 1,747 vehicles, latent demand of 38 vehicles
- Alternative 2 – 1,750 vehicles, latent demand of 35 vehicles
- Alternative 3 – 1,747 Vehicles, latent demand of 38 vehicles

Recommendation

Incorporating the geometric enhancements provided by Alternative 3 is recommended to improve the operations of the DDI and provide operational resiliency beyond the design year. Alternative 3 provides the most balance between traffic operations, site impacts, and future resiliency.

Introduction

The *Steese Expressway/Johansen Expressway Interchange Alternatives Analysis* determined a Diverging Diamond Interchange (DDI) to be the preferred interchange alternative at the intersection of Steese Expressway and Johansen Expressway (Steese-Jo) in Fairbanks, Alaska. HDR is tasked with advancing the Steese-Jo interchange design to construction. As part of the initial phase of detailed design, a Vissim 2021 microsimulation model analyzing the 2045 design year AM and PM peak periods was developed to validate long term operations, system resiliency, and identify enhancements to DDI geometry that could improve long term operations and resiliency.

The microsimulation model includes the entire project area extents:

- Northern Extent – Farmers Loop Road
- Southern Extent – W. Trainor Gate Road
- Western Extent – Old Steese Highway
- Eastern Extent – 500 feet along Lazelle Road

The purpose of the microsimulation model is to quantify the traffic operations of the preferred alternative, and to confirm the lane configuration, anticipated level of service (LOS), delay, and weaving operations along Steese Expressway. This memorandum details the traffic methodology to analyze and evaluate the operation of the DDI and includes geometric recommendations to improve the resiliency and traffic operations at the interchange with enhanced DDI options.

Volume Forecasting and Origin-Destination Studies

Volume Forecasts

The 2045 design year volumes were provided in the *Steese Expressway/Johansen Expressway Alternatives Analysis*. Annual Average Daily Traffic (AADT) was determined using the Fairbanks Area Surface Transportation Planning (FAST) travel demand model, which includes the planned widening and intersection capacity improvements along Old Steese Highway. Turning movement volumes were developed using the methodology found in the National Cooperative Highway Research Program (NCHRP) Report 765: Analytical Travel Forecasting Approaches for Project-Level Planning and Design. Documentation of the application of NCHRP Report 765, forecasted AADT within the project area, and forecasted peak-hour turning movement counts are provided in a Memorandum from Kinney Engineering, LLC, titled *Steese-Johansen Interchange: 2045 Turning Movement Forecasts*.

The FAST travel demand model included planned capacity improvements along Old Steese Highway, which runs parallel to Steese Expressway. The travel demand model showed an increase in AADT along Old Steese Highway and a slight decrease in AADT along the Steese Expressway south of the Johansen Expressway intersection. The increase in AADT along Old Steese Highway causes an increase in the eastbound left-turn volume at Steese-Jo, adding 225 vehicles to the forecasted eastbound left-turning movement volume, and totaling 1,785 vehicles during the 2045 PM peak period. This forecasted eastbound left-turn volume is the critical movement through the Steese-Jo DDI and should drive geometric and signal optimizations.

The design year turning movement volumes at Steese-Jo are provided in Figure 1 below.

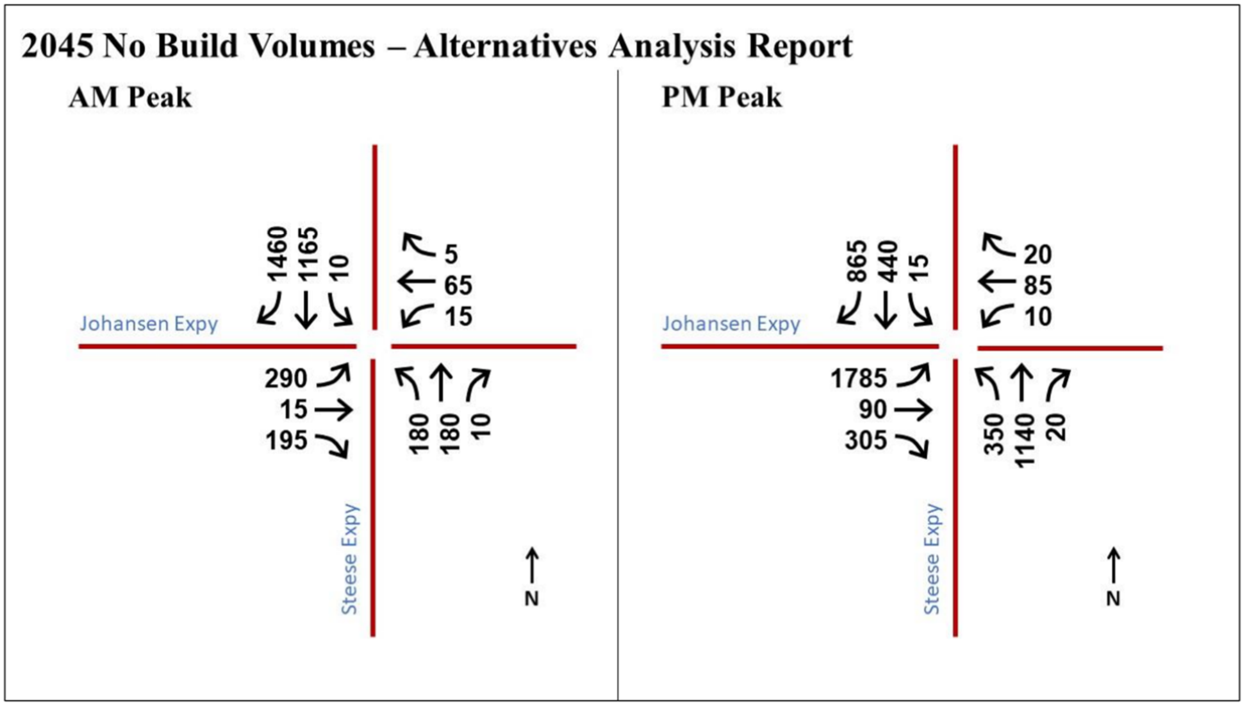

Figure 1. 2045 No Build AM and PM Peak Hour Steese-Jo Intersection Turning Movement Volumes

Origin-Destination Studies

The construction of the DDI will eliminate the conflict between the two movements carrying the largest volume in the PM, the eastbound left turn from Johansen Expressway and the northbound through-movement from Steese Expressway. While eliminating this conflict will greatly improve the intersection traffic operations, a DDI at Steese-Jo will also create a weave between the northbound entrance ramp gore and the Farmers Loop Road signalized intersection, located approximately 4,000 feet from the Steese-Jo intersection. The effective weave length of the DDI is anticipated to be between 1,800 and 2,000 feet. Additionally, due to a large northbound left-turn volume at Farmers Loop Road, an understanding of the origin-destination (OD) patterns within the project vicinity was required.

Wejo data was purchased and processed to determine OD patterns of vehicles travelling within the project area. Wejo provides anonymous time-stamped GPS data transmitted every few seconds from a vehicle's computer or navigation system. Two weeks of 24-hour Wejo data were provided within the project extents described above for summer 2019 and winter 2020. The data was processed to determine OD patterns and intersection turning movement percentages. Vissim was used to generate vehicle routing for the microsimulation model, replicating the OD patterns determined from the Wejo data and meeting the forecasted turning movement volumes.

Microsimulation Models

All microsimulation models include the interchange and the following adjacent signalized intersections:

- Farmers Loop Road/Steese Expressway
- Old Steese Highway/Johansen Expressway
- W. Trainor Gate Road/Steese Expressway

In order to deliver design year volumes unconstrained to the DDI, improvements were assumed at each of the adjacent intersections. The assumed improvements at each intersection are described below in Table 1.

Table 1. Assumed Improvements at Adjacent Signalized Intersections

Intersection	Proximity to Steese-Jo	Assumed Improvements
Farmers Loop Road at Steese Expressway	Approximately 4,000 feet north of Steese-Jo	• Signalized dual eastbound right-turn lane • Extension of northbound left-turn lanes • Adjustments to signal timing
Old Steese Highway at Johansen Expressway	Approximately 1,500 feet west of Steese-Jo	• Widened Old Steese Highway to a four-lane section • Two northbound left-turn lanes • Two northbound right-turn lanes • Two eastbound left-turn lanes • Two westbound left-turn lanes • Three eastbound through-lanes • Signal timing adjustments
W. Trainor Gate Road at Steese Expressway	Approximately 3,400 feet south of Steese-Jo	• Widened W. Trainor Gate Road west of intersection • Two northbound left-turn lanes • Two eastbound right-turn lanes • Signal timing adjustments

A majority of the improvements are not currently planned. The purpose of including the improvements was to analyze the Steese-Jo interchange unconstrained by the adjacent signals within the network. The improvements at Farmers Loop Road and recommended signal timing adjustments may be included in the Steese-Jo DDI design project. All other assumed improvements are not anticipated to be included as part of this project.

Design speeds, global driver behaviors, and reduced speed areas were coded within the models to best simulate the deceleration on approach to a left or right turn, desired turning speed, and acceleration out of the turn. Left-turn speed distributions were set to vary between 15 and 19 miles per hour (mph). Right-turn speed distributions were set to vary between 9 and 12 mph.

The output of the Vissim models includes the following:

- Average intersection delay
- Average movement delay at each intersection
- Maximum queue lengths
- Average vehicle speed along specific links

The Highway Capacity Manual Version 2010 LOS Criteria (refer to Exhibit 18-4) were used to determine the corresponding LOS for each intersection and individual movements at the intersection. The average vehicle speeds along segments were used to demonstrate capacity constraints at the eastbound left turn and to determine the weave operations along northbound Steese Expressway between the entrance gore and Farmers Loop Road. LOS D or better is considered acceptable for overall intersection delay, and LOS E or better is considered acceptable for individual movement delay.

Baseline DDI

The baseline DDI design was developed through the environmental process to minimize impacts on adjacent private property while providing overall intersection LOS of C or better in the design year. While the baseline DDI fulfills those criteria, its small footprint may result in operational challenges in the design year and beyond if growth projections are realized. Given the significant investment required for a new interchange, enhancements to ensure long-term resiliency of the interchange were investigated.

The overall operational results for the baseline DDI showed acceptable LOS, delay, and maximum queue lengths at the southbound and northbound ramp terminals. However, the eastbound through-movement at the west crossover experiences 80.9 seconds of delay, corresponding to an LOS F for the movement. The AM and PM peak period results for each ramp terminal are shown in Table 2 and Table 3.

Table 2. 2045 AM Baseline DDI Operational Results

Primary Road	Secondary Road	Approach	Movement	Movement				Intersection	
				Served Volume (vph)	Vehicle Delay (sec)	Movement LOS	Max Queue (ft)	Vehicle Delay (sec)	Intersection LOS
Johansen Expressway	Steese Hwy SB Exit Ramp	EB	EBT	75	3.2	A	44	7.0	A
			EBR	46	0.8	A	0		
		WB	WBL	3	3.0	A	11		
			WBT	59	27.6	C	61		
		SB	SBL	3	62.7	E	20		
			SBR	361	4.9	A	116		
Johansen Expressway	Steese Hwy NB Exit Ramp	EB	EBL	70	0.2	A	0	3.8	A
			EBT	7	2.4	A	17		
		WB	WBT	18	21.9	C	49		
			WBR	2	0.6	A	0		
		NB	NBL	44	2.3	A	11		
			NBR	2	6.9	A	24		

Table 3. 2045 PM Baseline DDI Operational Results

Primary Road	Secondary Road	Approach	Movement	Movement				Intersection	
				Served Volume (vph)	Vehicle Delay (sec)	Movement LOS	Max Queue (ft)	Vehicle Delay (sec)	Intersection LOS
Johansen Expressway	Steese Hwy SB Exit Ramp	EB	EBT	1730	80.9	F	1441	50.9	D
			EBR	299	6.9	A	1275		
		WB	WBL	10	1.6	A	186		
			WBT	431	26.1	C	227		
		SB	SBL	14	34.1	C	45		
			SBR	863	19.2	B	489		
Johansen Expressway	Steese Hwy NB Exit Ramp	EB	EBL	1640	7.8	A	380	9.8	A
			EBT	104	7.9	A	362		
		WB	WBT	94	37.0	D	146		
			WBR	19	2.2	A	48		
		NB	NBL	346	12.7	B	299		
			NBR	22	11.5	B	52		

The failing eastbound through-movement at the west crossover and overall LOS D of the intersection can be attributed to the fact that the demand volume for the eastbound left turn at the west crossover exceeds the capacity of the dual left-turn lane during the PM peak period. Comparing the served volume for the eastbound left turn at the northbound ramp terminal, an average of 1,640 vehicles over 10 microsimulation runs, to the demand volume of 1,785 vehicles results in a latent demand of 145 vehicles.

Although there are no studies that have determined the turning capacity of a free-flow left turn with a typical radius at a DDI, AASHTO does provide guidance regarding ramp capacity of a free-flow loop ramp. Per AASHTO Greenbook 10.9.3 (refer to page 10-48), a free-flow, single-lane loop ramp has a capacity ranging between 800 and 1,200 vehicles per hour, with the upper bound corresponding to a 30-mph design speed with a low percentage of heavy trucks. It is reasonable to assume that a free-flow left turn will realize similar capacity constraints that are determined by turning speed and driver behavior such as following distance and acceleration through a curve. Based on the capacity limits of a loop ramp, the theoretical capacity of a free-flow left turn from a DDI at an operating speed of 15 mph is between 700 and 800 vehicles per hour per lane, depending on the percentage of green time given to the movement at the crossover upstream of the left turn. Such geometric capacity constraints are not reflected in traditional analysis software, including Synchro and Vissim. Calibration of the movements were required to constrain the model's targeted capacity as dictated by the intersection geometry.

The impact of the geometric capacity constraints at the eastbound left turn onto Steese Expressway was observed in the PM peak microsimulation model. As the platoon of left-turning vehicles approached the free-flow left turn onto northbound Steese Expressway, a shockwave developed from vehicles decelerating from the design speed of the crossover, 25 mph, to the appropriate left-turn speed at the entrance ramp. Table 4 below shows the average eastbound vehicle speed between the ramp terminals for the AM and PM peak periods.

Table 4. 2045 AM and PM Eastbound Vehicle Speeds Between Ramp Terminals

Peak Period	Average Vehicle Speed (mph)
AM	27
PM	18

Because the eastbound approach and left-turn volume is significantly lower during the AM peak period compared to the PM peak period, the average vehicle speed during the AM peak period represents the desired free-flow speed between the ramp terminals. The lower average vehicle speed during the PM peak period can be attributed to the limited capacity of the dual eastbound left-turn lane. Although the PM peak period has an increase in demand, it is realistic to progress the eastbound traffic along the Johansen Expressway to allow the vehicles to arrive on green at the west crossover, maintaining 20–25 mph approach speeds. Additionally, the crossover intersections operate on a two-phase signal requiring half the cycle length of the Old Steese Highway/Johansen Expressway signal to the west. This allows any queue that develops at the west crossover to be served prior to the eastbound through-movement arriving from the signal upstream, also allowing the eastbound through-movements to maintain posted speeds as they approach the west crossover.

The shockwave along the eastbound travel lanes within the core of the interchange regularly extended beyond the southbound left-turn lane from the exit ramp and the west crossover intersection, causing cycle failure, resulting in an LOS F for the eastbound through-movement. Due to the opposing westbound through-volume and very low southbound left-turn volumes, the overall intersection delay was not impacted by the shockwave. However, if the southbound left-turn or westbound through-volumes increase even slightly, the shockwave described above and the subsequent congestion within the core of the interchange will cripple the capacity of the DDI, resulting in extensive queue lengths and ramp failure at the west crossover.

It is estimated that the eastbound left-turn demand volume will exceed the left-turn capacity in 2037. Using the 1,640 eastbound left-turning vehicles served in the microsimulation model as the maximum capacity of the left-turn lane and using linear regression of the forecasted turning movement volumes, it is estimated that the forecasted eastbound left-turn demand volume will be 1,648 vehicles during the PM peak period.

Enhanced DDIs

Three enhanced DDI alternatives were developed to increase the capacity of the eastbound left turn at the northbound ramp terminal and mitigate or eliminate the observed shockwave in the design year (2045). The geometric revisions include modifications to the east and west crossover intersections to align with 2019 AASHTO Greenbook DDI design criteria and Federal Highway Administration DDI design guidance.

Project constraints, such as impacts on the Birch Hill Cemetery, the Church of Jesus Christ of Latter-Day Saints (Church), and the Bentley Trust property located in the northeast, southeast, and southwest quadrants, respectively, were considered. Increases in bridge span and overall traffic operations were also considered. The enhanced DDI alternatives balance the project constraints and operational needs of the interchange. The geometric revisions and operational benefits for each alternative are described below.

Crossover Design Criteria

To improve the channelization of traffic through the crossover intersections, the point of curvature (PC) and point of tangency (PT) were placed outside of the intersection. Eliminating PCs and PTs within the crossover intersection allows a driver to traverse through the intersection without changing the direction of the steering wheel. This improves vehicular flow, enhances lane adherence, and provides a more intuitive crossover design. The enhanced DDI alternatives maintain tangent-on-tangent crossover intersections, providing the following minimum tangent lengths upstream and downstream of the crossover intersections:

- Upstream Minimum Tangent Length – 20 feet
- Downstream Minimum Tangent Length – 10 feet

Lane widths at the crossover intersections, including approach and departure curves, were increased from 12 feet to 14 feet. Wider lane widths at the crossover intersections allow for heavy trucks to manage the tighter curve radii at each crossover intersection. Increased lane widths also improve a driver’s ability to maintain lane adherence through the DDI. Wider lane widths will increase the roadway width to be maintained during snow events; however, it is not anticipated to have a negative impact on the snow-plowing operations. The overall increase in roadway width is 4 feet in each direction, which will not require additional passes or equipment to clear the roadway of snow.

The crossover intersection spacing was increased between 33 and 66 percent, depending on the enhanced DDI alternative. Increasing the crossover intersection spacing provides the following benefits:

- Improves signal coordination and timing, allowing for improved vehicular progression through the DDI.
- Increases storage within the core of the interchange.
- Facilitates a larger eastbound left-turn radius while balancing increased structure length.

The disadvantage of increasing the crossover intersection spacing is additional right-of-way impacts on the Church located in the southeast quadrant. Impacts to this parcel were identified during the *Steese Expressway/Johansen Expressway Interchange Alternatives Analysis* with the impact potentially requiring relocation of the Church building and parking lot. All enhanced DDI alternatives will require acquisition of the parcel and relocation of the Church.

A typical DDI provides a horizontal curve downstream of the crossover, tying into the tangent section that makes up the core of the interchange. Due to the heavy eastbound left-turn volume and the limiting capacity of a regular left turn, it is desirable to maintain a higher operating speed upon approach of the eastbound left turn. The enhanced DDI alternatives eliminate the eastbound horizontal curve downstream of the west crossover and maintain the eastbound tangent alignment through the west crossover to the PC of the eastbound left turn. Eliminating the horizontal curve downstream of the crossover while increasing the radius of the eastbound left turn will reduce the potential for a shockwave to develop during the PM peak period and increase the capacity and throughput of the eastbound left turn.

Enhanced DDI Alternative 1 – 150-foot Eastbound Left-Turn Radius

The baseline DDI provided an 88-foot radius curve for the eastbound left turn, measured from the inside lane line, corresponding to an average turn speed of 15 mph. As described above, the turn radius and speed will limit the capacity of the turn lanes. Enhanced DDI Alternative 1 increases the curve radius at the eastbound left turn to 150 feet, corresponding to an average turn speed of 20 mph. Figure 2 shows the general footprint of enhanced DDI Alternative 1 superimposed over the baseline DDI.

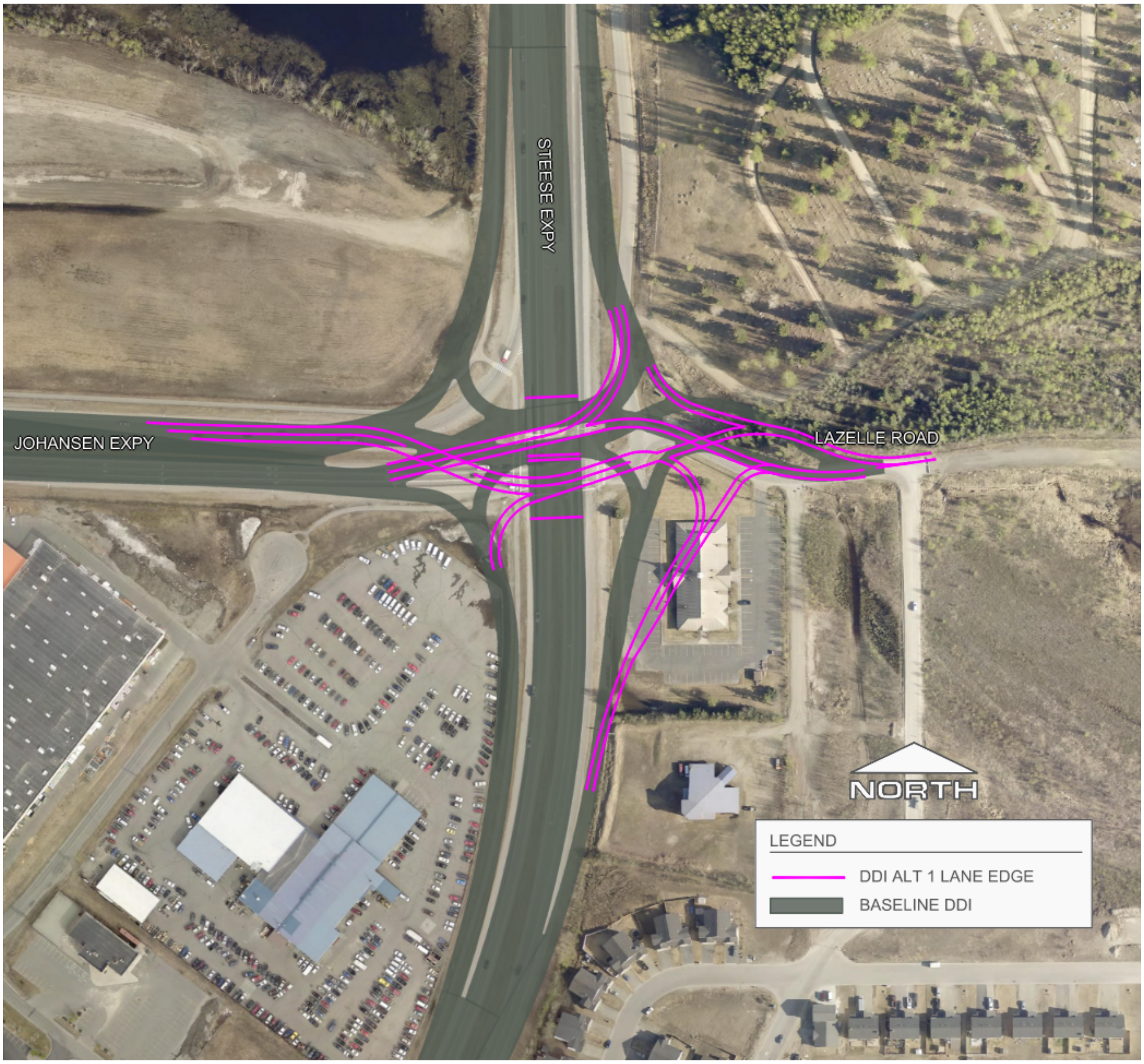

Figure 2. Enhanced DDI Alternative 1

The operational results for enhanced DDI Alternative 1 during the PM peak period showed an increase in the eastbound left turn throughput of 107 vehicles, improvement of the eastbound through movement from an LOS F to a C, and a reduction in overall intersection delay at the west crossover of 24.1 seconds. The average eastbound left-turn volume served during the PM peak period over 10 microsimulation runs was 1,747 vehicles, leaving 38 vehicles unserved during the analysis period. This unserved 2 percent of the eastbound left-turn demand volume is a function of the signal timing and analysis period and not a result of capacity limits of the eastbound left-turn lanes. No shockwaves within the core of the interchange were observed, and the average operating speed through the eastbound left turn was 18 mph. Table 5 shows the 2045 PM peak period operational results.

Table 5. 2045 PM Peak Operational Results – Enhanced DDI Alternative 1

Primary Road	Secondary Road	Approach	Movement	Movement				Intersection	
				Served Volume (vph)	Vehicle Delay (sec)	Movement LOS	Max Queue (ft)	Vehicle Delay (sec)	Intersection LOS
Johansen Expressway	Steese Hwy SB Exit Ramp	EB	EBT	1839	34.3	C	1233	26.8	C
			EBR	309	5.4	A	1103		
		WB	WBL	10	0.4	A	0		
			WBT	431	26.7	C	333		
		SB	SBL	14	32.2	C	48		
			SBR	863	18.7	B	494		
Johansen Expressway	Steese Hwy NB Exit Ramp	EB	EBL	1747	3.4	A	300	5.7	A
			EBT	106	4.6	A	82		
		WB	WBT	94	37.4	D	163		
			WBR	19	1.3	A	0		
		NB	NBL	346	8.9	A	0		
			NBR	22	6.2	A	0		

Enhanced DDI Alternative 2 – 230-foot Eastbound Left-Turn Radius

Enhanced DDI Alternative 2 increases the curve radius at the eastbound left turn to 230 feet, corresponding to an average turn speed of 25 mph. Figure 3 shows the general footprint of enhanced DDI Alternative 2 superimposed over the baseline DDI.

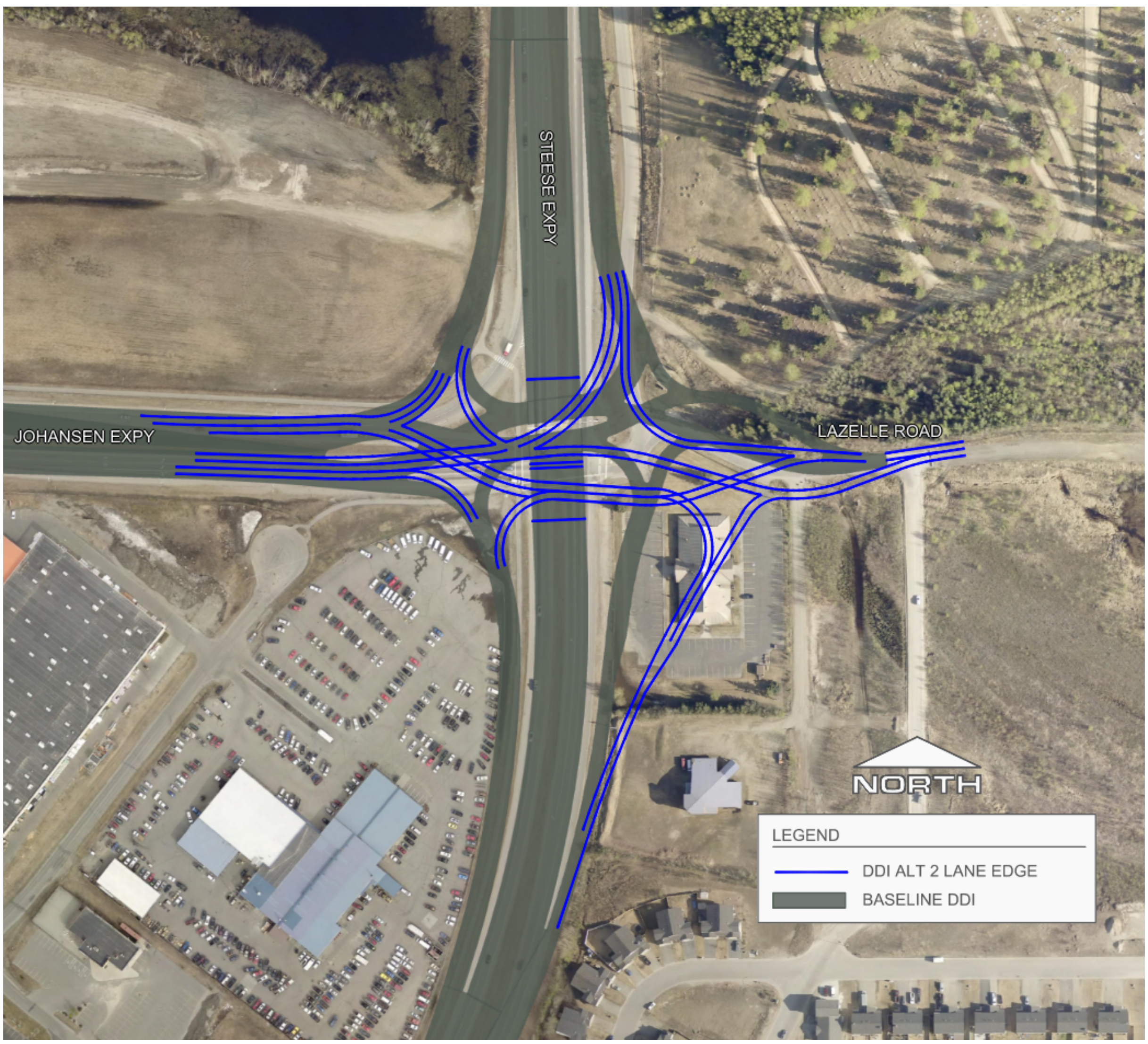

Figure 3. Enhanced DDI Alternative 2

The operational results for enhanced DDI Alternative 2 during the PM peak period showed an increase in the eastbound left-turn throughput and improved LOS and reduction in delay. The average eastbound left-turn volume served during the PM peak period over 10 microsimulation runs was 1,750 vehicles, leaving 35 vehicles unserved. This unserved 2 percent of the eastbound left-turn demand volume is a function of the signal timing and analysis period and not a result of capacity limits of the eastbound left turn lanes. No shockwaves within the core of the interchange were observed, and the average operating speed through the eastbound left turn was 22 mph. Table 6 shows the 2045 PM peak period operational results.

Table 6. 2045 PM Peak Operational Results – Enhanced DDI Alternative 2

Primary Road	Secondary Road	Approach	Movement	Movement				Intersection	
				Served Volume (vph)	Vehicle Delay (sec)	Movement LOS	Max Queue (ft)	Vehicle Delay (sec)	Intersection LOS
Johansen Expressway	Steese Hwy SB Exit Ramp	EB	EBT	1842	25.2	C	1143	22.0	C
			EBR	309	4.7	A	979		
		WB	WBL	10	0.4	A	232		
			WBT	430	27.1	C	305		
		SB	SBL	14	32.8	C	49		
			SBR	863	19.0	B	507		
Johansen Expressway	Steese Hwy NB Exit Ramp	EB	EBL	1750	3.0	A	177	5.5	A
			EBT	106	4.7	A	83		
		WB	WBT	94	37.3	D	147		
			WBR	19	0.7	A	7		
		NB	NBL	346	9.5	A	112		
			NBR	22	10.9	B	0		

Enhanced DDI Alternative 3 – 155-foot Eastbound Left-Turn Radius with East Crossover Shifted South

Enhanced DDI Alternative 3 is a combination of Alternative 1 and 2. Similar to Alternative 1, but the eastbound left turn radius is increased slightly to 155 feet, corresponding to an average turn speed of 20 mph. The location of the east crossover is shifted to the southeast, similar to the proposed location in Alternative 2. Positioning the east crossover in the southeast allows for a reduction in impact to the Birch Hill Cemetery while keeping full access to/from D Street. Figure 4 shows the general footprint of enhanced DDI Alternative 3 superimposed over the baseline DDI.

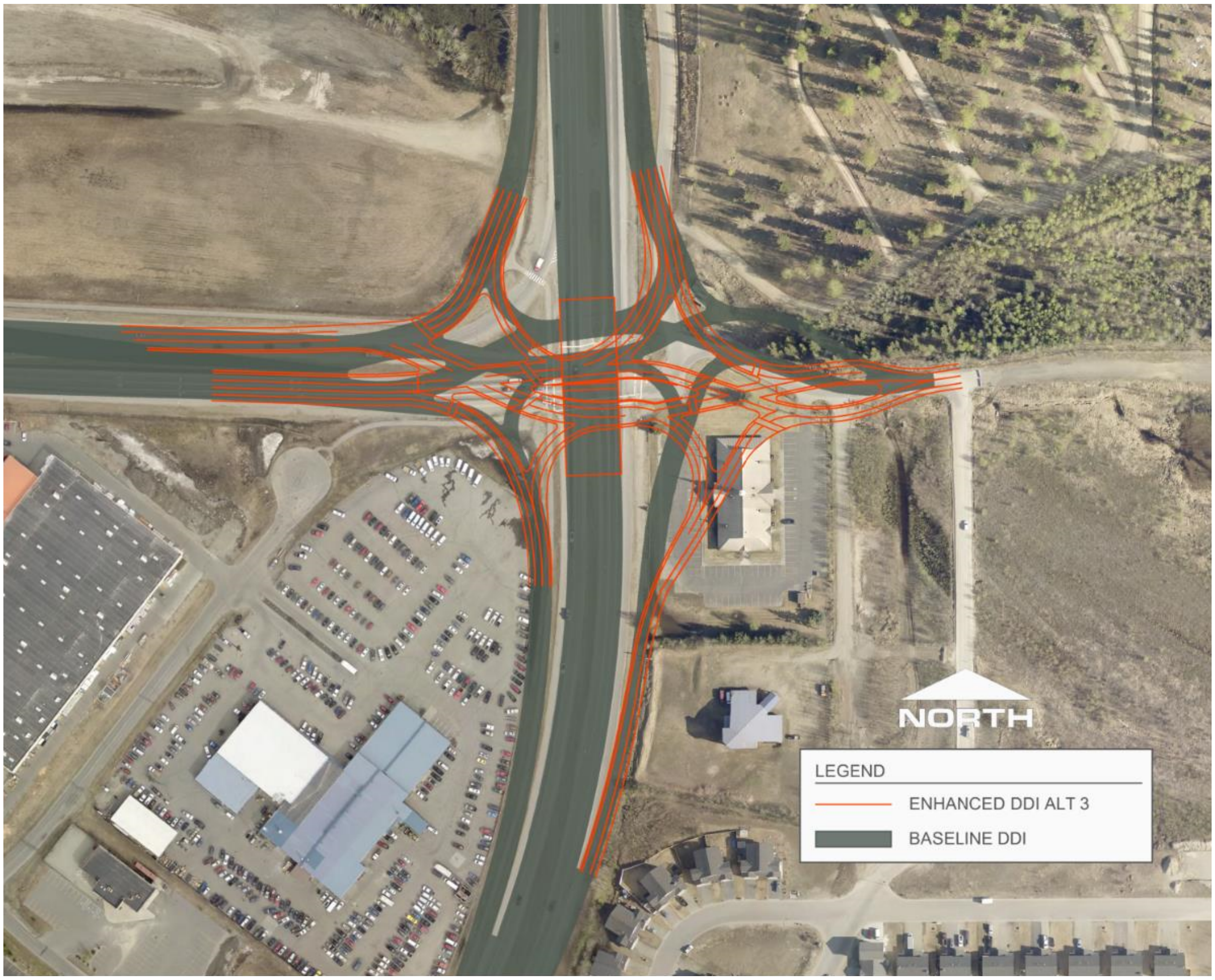

Figure 4. Enhanced DDI Alternative 3

The operational results for enhanced DDI Alternative 3 during the PM peak period showed an increase in the eastbound left turn throughput of 107 vehicles, improvement of the eastbound through movement from an LOS F to a C, and a reduction in overall intersection delay at the west crossover of 29.4 seconds. The average eastbound left-turn volume served during the PM peak period over 10 microsimulation runs was 1,747 vehicles, leaving 38 vehicles unserved during the analysis period. The unserved 2 percent of the eastbound left-turn demand volume is a function of the signal timing and analysis period and not a result of capacity limits of the eastbound left-turn lanes. No shockwaves within the core of the interchange were observed, and the average operating speed through the eastbound left turn was 18 mph. Table 7 shows the 2045 PM peak period operational results.

Table 7. 2045 PM Peak Operational Results – Enhanced DDI Alternative 3

Primary Road	Secondary Road	Approach	Movement	Movement				Intersection	
				Served Volume (vph)	Vehicle Delay (sec)	Movement LOS	Max Queue (ft)	Vehicle Delay (sec)	Intersection LOS
Johansen Expressway	Steese Hwy SB Exit Ramp	EB	EBT	1839	29.4	C	1187	24.3	C
			EBR	309	4.4	A	1023		
		WB	WBL	10	0.5	A	0		
			WBT	431	28.2	C	279		
		SB	SBL	14	32.3	C	47		
			SBR	863	18.7	B	504		
Johansen Expressway	Steese Hwy NB Exit Ramp	EB	EBL	1747	4.2	A	326	6.3	A
			EBT	106	5.0	A	81		
		WB	WBT	94	37.2	D	147		
			WBR	19	0.8	A	7		
		NB	NBL	346	8.6	A	147		
			NBR	22	13.7	B	0		

Comparison of Enhanced DDI Alternatives

All three enhanced DDI alternatives improve the capacity and resiliency of the Steese-Jo DDI. Table 8 below provides a high-level overview of the benefits, project impacts, and design challenges for each alternative.

Table 8. Enhanced DDI Alternative Benefits and Impacts

Alternative	Benefits	Project Impact/Design Challenges
Enhanced DDI Alternative 1	• Acceptable LOS for all movements (no failing movements) • Significantly reduced potential of shockwave • More typical to a traditional DDI layout • Span length can accommodate decked bulb T-girder	• Additional right-of-way impact • Will require 2 span decked bulb T-girder structure • Increase in bridge length
Enhanced DDI Alternative 2	• Acceptable LOS for all movements (no failing movements) • Eliminates shockwave • Eastbound left-turn demand volume served • Higher eastbound left-turn speed • Span length can accommodate decked bulb T-girder	• Additional right-of-way impact • Will require 2 span decked bulb T-girder structure • Increase in bridge length • Relocation of D Street or restriction to right-in/right-out or construction of roundabout required • May be difficult to sign
Enhanced DDI Alternative 3	• Acceptable LOS for all movements (no failing movements) • Significantly reduced potential of shockwave • More typical to a traditional DDI layout • Span length can accommodate decked bulb T-girder • Maintains full access to/from D Street • Wider pedestrian path within median	• Additional right-of-way impact • Will require 2 span decked bulb T-girder structure • Increase in bridge length

Comparing the project impacts/design challenges between the alternatives the differences are the signing and maintaining full access at D Street. Enhanced DDI Alternative 1 and 3 will be signed as a typical DDI, providing overhead sign structures to guide drivers into the correct lanes. Enhanced DDI Alternative 2 will have similar overhead sign structures; however, due to the location of the eastbound diverge to turn north on Steese Expressway or continue eastbound onto Lazelle Road, signing the diverge may be difficult. Further analysis and investigation would be necessary to determine a feasible signing plan. Alternatives 1 and 3 also maintain full access to/from D Street while Alternative 2 may require D Street to be right-in-right-out.

Weave Operations

All microsimulation models showed acceptable weave operations along northbound Steese Expressway between the northbound entrance ramp gore and Farmers Loop Road. Free-flow speeds along this segment are expected to be between 40 and 50 mph. This is less than the posted speed limit; however, because Farmers Loop Road is signalized, vehicles will be decelerating at times along the segment analyzed. Table 9 shows the average operating speed along Steese Expressway within the weave segment.

Table 9: 2045 Northbound Steese Expressway Average Operating Speeds

Alternative	Peak Period	Average Vehicle Speed (mph)
Baseline DDI	AM	48
Baseline DDI	PM	43
Enhanced DDI Alternative 1	PM	41
Enhanced DDI Alternative 2	PM	41
Enhanced DDI Alternative 3	PM	41

The baseline DDI during the AM peak period represents the free-flow speed when no congestion is present along the northbound Steese Expressway. The reduced operating speeds during the PM peak period are a result of longer queue lengths at Farmers Loop Road, requiring vehicles to begin decelerating sooner. The difference in average vehicle speeds between the baseline DDI and the enhanced DDI alternatives is due to the increased volume delivered by the enhanced DDIs.

Recommendation

The geometric review and traffic analysis of the baseline DDI identified the following design year operational challenges with the current DDI design:

- Capacity constraints of the eastbound left turn may not meet LOS standards for design year volumes.
- Shockwaves may occur within the core of the interchange, queuing into the west crossover.
- Queue spillback would cause the eastbound through-movement to fail at the west crossover.
- Geometric design criteria for standard DDIs are not met:
    - Crossover intersection spacing is not ideal for signal progression, and
    - PCs and PTs are located within the crossover intersections.

All three enhanced DDI Alternatives address the challenges listed above. All alternatives increase the turning capacity of the eastbound left turn, meet geometric design criteria for DDI crossovers, and provide a more resilient interchange. The enhanced DDI alternatives balance project constraints, such as bridge lengths and right-of-way impacts, while addressing the critical geometric elements necessary to meet projected design year traffic at the Steese-Jo interchange. Alternative 3 best balances the geometric footprint of the DDI while reducing the impacts at Birch Hill Cemetery and maintaining access to D Street. Alternative 3 improves overall capacity and future resiliency. It is recommended to incorporate the geometric enhancements provided by Alternative 3 to improve the operations of the DDI and provide operational resiliency beyond the design year.